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Abstract

A reevaluation of design floods for dam safety within the United States showed that the need to modify dams to accommodate larger floods has greatly increased in recent years. The occurrence of larger design floods would result in overtopping of the dams at many existing reservoirs due to insufficient storage or release capacity. When the addition of storage or release capacity becomes impractical or too costly, dam owners must sometimes resort to providing overtopping protection.

An ASCE Hydraulics Division Task Committee on Alternatives for Overtopping Protection for Dams was established in 1991 to inventory and evaluate modification alternatives for new, innovative spillway designs and overtopping protection concepts for dams. Results of this task committee are being prepared for publication by ASCE during late 1992. This paper provides an overview of some recent research and prototype applications of several alternatives for overtopping protection and some modifications to prevent overtopping.

Introduction

With the growing concern about dam safety throughout the world and increasing awareness of the hydrologic inadequacy of many older dams, many engineers and dam designers are now looking to innovative alternative designs in modifying these dams. Most traditional modification

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alternatives to remedy this problem, such as providing additional reservoir storage or enlarging the spillway capacity, are often too costly. Some innovative designs for spillways, outlet works, and overtopping protection for dams are being developed in several countries that should reduce costs and provide a reasonable degree of safety for both new and existing projects.

During the last several years, research in the United States, US, and the United Kingdom, UK, has increased the list of alternative designs available to engineers. Based on recent and ongoing overtopping protection research, the Federal Energy Regulatory Commission FERC has decided that embankment protection has sufficient merit to allow consideration on a project-specific basis (Frizell, et al 1991). The use of traditional in situ reinforced concrete has been enhanced as a major choice to achieve reliable stability and performance due to improvements in design methods and placements. Roller-compacted concrete, RCC, and cellular concrete mats, CCM, or precast concrete blocks have recently been used on several embankment dams in the US at a significant cost savings.

Dam Modifications to Prevent Overtopping

Some of the alternatives used to modify existing dams to prevent overtopping during larger design floods are labyrinth weir spillways, fuseplug spillways, raised earthwork and parapet walls. Results from a collection of 140 high hazard prototype projects indicated that 92 projects were modified to prevent overtopping using a variety of these methods as shown in Figure 1.

Overtopping Protection for Existing Dams

Of the 140 projects modified to accommodate the probable maximum flood, PMF, 48 provided overtopping protection. These methods include geotextiles, gabions, precast concrete blocks, cable-tied cellular concrete mats, in situ concrete, reinforced concrete slab, and RCC as shown in Figure 2.

The use of precast concrete blocks to prevent overtopping erosion was first researched and used in the UK by the Construction Industry Research and Information Association (CIRIA). The wedge-shaped blocks were developed and used first in the USSR. Recent laboratory research both in the U.S. and UK have greatly advanced the design parameters for the wedged-shaped block protection systems.

pressures on the stepped face and to resulting energy dissipation (Frizell 1991).

Future Challenge

With the recent research and prototype experience currently available, engineers can be more confident in preparing designs for overflow protection for low to medium embankment dams. The continuing challenge is to provide reliable cost-effective prevention of overflow or adequate protection of high embankment dams to accommodate overtopping. The USBR has already faced this challenge on projects like A. R. Bowman Dam, a 48.5-m-high earth-and rock-fill embankment located in central Oregon that is projected to be overtopped by flow depths up to 6.1 m during the PMF. Four concrete overtopping protection alternatives were evaluated for A. R. Bowman: RCC overlay with steps, RCC without steps, continuously reinforced concrete CRC overlay with steps, and the chosen smooth CRC slab (Hensley-Henning 1991).

Summary

Based upon a recent survey of prototype experience in the modification of dams to accommodate larger floods, the majority (about two-thirds) of projects were modified to prevent overtopping flows. The other one-third (48 of 140 projects) provided a variety of overtopping protection. In situ concrete and RCC were the two most common types of overtopping protection. Precast concrete block systems are gaining in usage as a cost-effective alternative for low-head overtopping protection due to recent research showing that they can provide sufficient stability to perform reliably under steeply sloped high-velocity flow conditions. In the near future precast or cellular concrete mats may be the most cost-effective overtopping alternate for many typical low-head projects, subject to availability and proximity of materials and equipment. Following proper design procedures and selecting appropriate block type, weight, and dimensions are critical to reliable performance. Further full-scale model tests and actual field performance are needed to verify various aspects of the CCM's and other related overtopping protection systems. Based on recent and ongoing overtopping protection research, the FERC has decided that embankment protection has sufficient merit to allow consideration on a project-specific basis.

Prevention of overtopping by various modifications to increase storage or flood release capacity using traditional or innovative measures should remain the first consideration.

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